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DATA COMMUNICATIONS

INTRODUCTION

Computers are used to generate information. Generated information is not useful in itself. The information must be delivered to the individuals who use it, and it must be delivered in a timely fashion. Often, the information must be transmitted from one location to another. This process is called data communication. Here, we will be concerned with the hardware, software and procedures used in data communication.

Communication, the transfer of information, is the basis of office automation. Advances in communication technology, combined with rapidly evolving computer technology, have made possible much of the progress in the field. Electronic communication consists of telecommunication and data communication. Telecommunication is the use of telephone, teletypewriting, telegraph, radio, or television facilities to transmit information, either directly or via the computer. Data communication is the transfer of data or information between computer-devices. Office automation integrates the two.

Data communication is so common that each of us has probably seen it in action without thinking much about it. Some examples of everyday data communication are:

1. Airlines Reservations: When you reserve seats on an airplane flight, the agent enters the reservation on a terminal connected to the airline's computer. Since the computer is usually located far from the agent (sometimes several thousand miles away), data communication must be used to relay data from the terminal to the computer and back.
2. Automated Banking: Most banks now provide a wide range of banking services through automatic teller machines (ATMs). Users can make deposits and withdrawals, check balances, and even pay utility bills through the machines. An automatic teller machine is connected to the bank's main computer, which

may be located at the other end of the city or even in another state. The transaction request is sent to the computer using a data communication system.

3. **Point-of-Sale Terminals:** Many retail stores use point-of-sale terminals instead of cash registers. These terminals send records of sales to a central computer, which maintains accounting and inventory records.

Communication offers so many opportunities, it is tough to know where to begin. You can turn your personal computer into a terminal and take advantage of massive mainframe processing power. If you are feeling sociable, you can send an electronic letter to a friend or even meet new people through an on-line service. Best of all, you can access huge reserves of information on virtually any subject. Once you are on-line, you may find linking up with the outside world a fascinating addiction.

Along with these attractions, mysteries abound. In fact, communication is one of the most difficult computer applications to comprehend. In the self-contained quarters of word processing, spreadsheets and data base management, all you need worry about is your PC and its software. As Figure 2.1 illustrates, linking up with the outside world adds a whole new set of considerations. Your system, a modem (modulator-demodulator), a communications network, and the remote computer's hardware and software must work in tandem for a successful exchange of data to take place.

DATA COMMUNICATION

Data communication is the active process of transporting data from one point to another. Networks are communication systems designed to convey information from a point of origin to a point of destination. Note that they are communication systems, not computer systems. The operative word is communication, the transfer of information from one person or device to another.

Networks come in two flavours: local as in local area networks, which cover a small area and have a finite, relatively small, number of users; and global or long-haul, which cover great distances and have an unlimited number of users. Telephone networks are long-haul networks.

Two basic principles govern the operation of a communication system: first, the system exists to transfer information from one point to another. All services supported by the network are designed to facilitate this exchange of information. Second, the receiver must understand the message. Without understanding, no communication takes place.

To be useful, the data communication network (or any communication system) must be able to accept input data; structure the data so that it can be sent quickly and accurately; transmit the data to a specific destination; and once the data has arrived, reconvert it to a form understandable by the destination.

DATA COMMUNICATION SYSTEM

A data communication system consists of five basic components, as shown in

Figure 2.1, but there are many possible variations. Figure 2.2 shows a typical telecommunication configuration. The five basic components are:

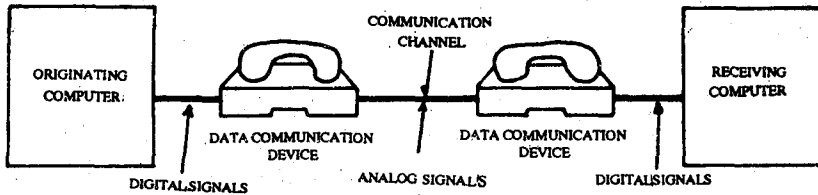


Fig. 2.1 : The components of a Data communication system



Fig. 2.2 : The basic elements that make up a communications link between two computer systems

1. The sending or originating computer. The originating computer or terminal has data to transmit. The data may consist of a file on a disk or may be entered on a keyboard, transmitted as it is typed.
2. A data communication device attached to the sending computer. The data communication device converts the data into a form that can be transmitted.
3. A communication channel. The communication channel (also called a communication link) carries the data from place to place. There are many possible communication channels, including telephone lines and microwave relay systems.
4. A data communication device attached to the receiving computer. This data communication device converts the transmitted data into a form that the receiving computer can understand.
5. The receiving computer. The receiving computer or terminal receives the data, displays them on a screen, prints them or stores them in a file.

DATA COMMUNICATION SOFTWARE

Most computer applications, including data communication, require both appropriate hardware and software. Specialised data communication software is required to set up a communication link between two computers and to transmit data.

Data communication software performs a number of jobs. One is to send data at the proper speed; if the receiving and sending computers do not agree on the

communication rate, the receiving computer will not be able to understand the communication. Another job is to monitor signals from the receiving computer that indicate any transmission errors.

The communication programme you choose plays a key role in data exchange between computers. If you are on the receiving end, communication software lets you decide whether you want to save data to disk, send it to a printer or simply let it scroll off the screen. When you transmit data, most programmes let you choose between sending it from a disk file or typing it directly from the keyboard.

Software for communication also stores telephone numbers, modem commands and other critical settings. Usually, these parameters reside in a dialling directory, so you do not have to re-enter them each time you want to hook up with a remote system. A well-designed communication programme makes it easy to select a remote system from the directory and begin connection procedures.

Many communication programmes direct modems to dial, hang up and answer incoming calls automatically. While it is the modem that actually performs these tasks, the software provides the appropriate instructions. For example, when the programme sends the modem a dial command and a phone number, the modem automatically goes off-hook (the same as lifting a telephone handset), waits for a dial tone, and proceeds to generate click pulses or tones that dial the number.

Most modems provide an audible indication that dialling is in progress, followed by a signal that a connection has been made. You will hear the modem beeping out tones like fast fingers on a touch-tone phone. Then, if all goes well, you should hear the remote system's line ring and the remote modem "pick up" the call. The remote modem then generates a high-pitched answer tone, to which your modem responds with a burst of tones of its own. This opening interchange is called handshaking. Once two modems are locked on to each other, most communication programmes display a 'Connect' message on screen.

In the foregoing paras, we listed the rudimentary features of a communication programme but a typical one has many additional features. Some programmes allow users to redial a number repeatedly (if the line is busy, for example) until a connection is made, and others allow users to take remote control of the computer at the other end. That is, the programme user can control the other computer from his own keyboard. This allows communication with no one in attendance at the other end. Some programmes allow users to dial a sequence of numbers one after the other. These are sometimes used to generate recorded advertising calls.

DATA COMMUNICATION CONCEPTS

1. Common Ground: The ASCII Standard

The first step toward understanding communication is to look at computer data at its most basic level. Computers manage, store and exchange data using electronic pulses that come in only two varieties: high and low. A device using digital signals can differentiate only between the presence ("on") and absence ("off") of electronic

impulses; "on" equals the numeral one and "off" equals zero. Numerically, these types of pulses are represented in binary form as either a 1 (one) or a 0 (zero). The use of these two digits in various combinations to express any numeric quantity is known as binary arithmetic and the two numerals are called binary digits. A bit, a contraction of binary digit, is the smallest element of data or information dealt with by digital equipment. For convenience, bits are sometimes combined into larger units (usually groups of eight) called bytes.

Every character (letter, numeral, symbol or punctuation mark) is composed of a group of eight bits called byte. The way the bits are arranged within each byte, that is, the order in which the 1s and 0s appear, determines which character a byte represents. The meaning of the bits and bytes is determined by the coding data of within the computer for the computer's own use and if transmission. To avoid enormous incompatibility between systems, the computer industry has created a number of standards that establish hard-and-fast relationships between bit combinations and their corresponding characters. The diversity of codes in use is one source of incompatibility, a principal handicap in office automation.

Coding, the language of digital equipment, represents alphanumeric characters, special characters (such as #, @, *), and equipment-control characters (such as carriage returns) in terms of bits. The common expressions, "five-bit code", "five-unit code" or "five-level code", all indicate the number of bits required to represent each of the alphanumeric or other characters.

Many different codes have been developed for use in data processing. The American Standard Code for Information Interchange (ASCII) character set is the most widely used coding convention for all computers, used both for internal computer data manipulation and for communication with other devices.

ASCII is a seven-bit code; that is, it uses seven bits to define each character. As the number of bits per character determines the maximum number of characters in the code, the basic ASCII code can represent 128 characters, covering upper- and lower-case letters, numbers, punctuation marks and special characters known as control characters. Table 2.1 lists the complete ASCII character set.

TABLE 2.1 : ASCII Character Set

ASCII Value	Character	Translation	ASCII Value	Character	ASCII Value	Character
000	NUL	(null)	046	.	092	\
001	SOH	(start of header)	047	/	093]
002	STX	(start of text)	048	0	094	^
003	ETX	(end of text)	049	1	095	
004	EOT	(end of transmission)	050	2	096	.
005	ENQ	(enquiry)	051	3	097	a
006	ACK	(acknowledge)	052	4	098	b
007	BEL	(bell)	053	5	099	c
008	BS	(backspace)	054	6	100	d

009	HT	(horizontal tab)	055	7	101	e
010	LF	(line feed)	056	8	102	f
011	VT	(vertical line)	057	9	103	g
012	FF	(form feed)	058	:	104	h
013	CR	(carriage return)	059	;	105	i
014	SO	(shift out)	060	<	106	j
015	SI	(Shift in)	061	=	107	k
016	DLE	(data link escape)	062	>	108	l
017	DC1	(data control 1)	063	?	109	m
018	DC2	(data control 2)	064	@	110	n
019	DC3	(data control 3)	065	A	111	o
020	DC4	(data control 4)	066	B	112	p
021	NAK	(negative acknowledgement)	067	C	113	q
022	SYN	(synchronization)	068	D	114	r
023	ETB	(end of transmission block)	069	E	115	s
024	CAN	(cancel)	070	F	116	t
025	EM	(end of medium)	071	G	117	u
026	SUB	(substitute)	072	H	118	v
027	ESC	(escape)	073	I	119	w
028	FS	(file separator)	074	J	120	x
029	GS	(group separator)	075	K	121	y
030	RS	(record separator)	076	L	122	z
031	US	(unit separator)	077	M	123	{
032	SP	(blank space)	078	N	124	—
033	!		079	O	125	}
034	"		080	P	126	=
035	#		081	Q	127	DEL
036	\$		082	R		
037	%		083	S		
038	&		084	T		
039	,		085	U		
040	(086	V		
041)		087	W		
042	*		088	X		
043	+		089	Y		
044	'		090	Z		
045	-		091	[

Control characters are used to give instructions. The control characters may precede, accompany or follow a block of information. Most control characters are nonprinting: they trigger an action rather than producing a readable letter or number. Control characters may affect the following activities:

- Processes occurring within a document, such as a tab or sounding a bell.
- Processes to be performed by another device, for example, a form feed on a printer.
- Communications, which indicate the start and stop of a message or acknowledge receipt of data.

This code assigns a different number to each letter of the alphabet (with separate numbers for upper-case and lower-case), as well as to each numeric digit, each common punctuation mark and several special symbols. Table 2.2 shows some examples of keyboard characters and their ASCII code values in both decimal and binary form. The letter A, for example, corresponds to the decimal number 65, which is equivalent to the binary number 01000001.

TABLE 2.2: Keyboard characters and their decimal and binary equivalents

Character	ASCII code	
	Decimal	Binary
A	65	01000001
a	97	01100001
3	51	00110011
!	33	00100001
<Ctrl>C	3	00000011

During a communication session, a computer transmits a byte representing the letter A starting with the on the bit extreme right: first a 1, then five 0s, a 1 and a final 0. At the receiving end, that series of bits is compared with a built-in electronic ASCII table, which translates 01000001 into the letter A.

Obviously, a misplaced 1 or 0 in a stream of bits means the receiving computer will come up with the wrong ASCII character. The slightest crackle on the telephone lines can cause this kind of error. Fortunately, most communication programmes use bits added to each character to detect and correct mistransmission.

The standard ASCII table contains characters numbered from 0 through 127. The PC and many other computers assign ASCII values to an additional set of 128 characters, up to number 255. Characters in this second group are called high-bit characters, because the eighth bit of each byte is always a 1 or high.

However, no universal standard exists for high-bit ASCII characters. On the PC and compatibles, this character set consists of foreign language symbols and graphics characters. But on other computers, high-bit characters are entirely different or even nonexistent. Therefore, to send or receive ASCII high-bit graphics and foreign language characters, a PC or a compatible is needed on both ends of a communication link.

2. Units of Measure

Hertz and bandwidth define the volume of signals that can be transmitted through communication channels. Hertz measures the speed of electromagnetic waves, which oscillate up and down. From the top centre of one curve to the same point on the next curve represents one cycle, as depicted in Figure 2.3. One wave passing by in one second or one cycle per second, equals one Hertz (Hz). Kilohertz (KHz, thousands of hertz), megahertz (MHz, millions of hertz) and gigahertz (GHz, billions of hertz) are the units most frequently encountered in office automation or data communication.

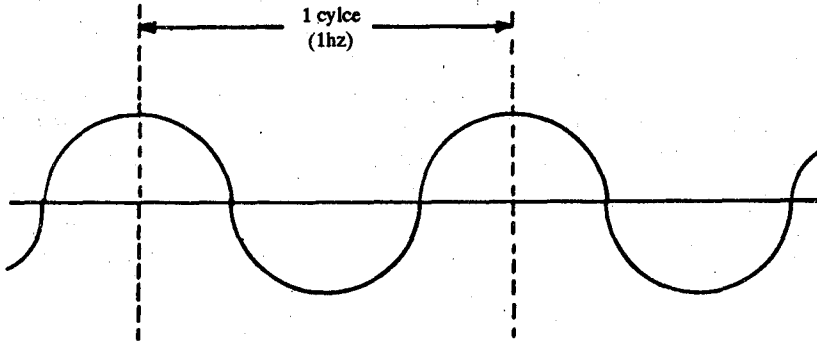


Fig. 2.3 : Direction of "wave" motion --> Electromagnetic waves

Bandwidth, expressed in Hertz, defines the minimum and maximum volume of cycles that can be sent through a transmission channel in one second, and thus, the amount of information can be transmitted in one second (see Figure 2.4). In the transmission of electronic signals, bandwidth is critical. A typical voice-grade telephone circuit has a bandwidth of 300 to 3,400 hertz, which is a narrowband channel. A VHF (Very High Frequency, 30-300 MHz) broadcast television signal requires a transmission capability of up to 300 megahertz (300 million cycles per second), which is considered a broadband channel. It is not possible to transmit television signal through a standard telephone circuit, because the electronic path is too narrow.

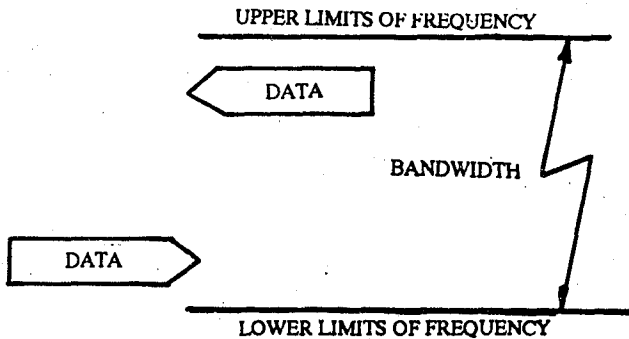


Fig. 2.4 : Bandwidth

Baseband is a signalling technique in which the signal is transmitted in its original form and not changed by modulation. Broadband makes use of multiple channels over the same medium by frequency division of the bandwidth.

3. Communication Rate

The speed at which data travel over a communication channel is called the communication rate (also known as the transmission speed). This rate is sometimes measured in bits per second or baud. The number of signalling elements transmitted

per second is the baud rate. One baud equals a communication rate of one bit per second. For devices using digital signals, the baud rate is usually expressed in terms of an approximate equivalent, bits per second. Thus, to say that a device can communicate at 300 baud usually means it can transmit or receive a maximum of 300 bits (roughly 30 characters) per second (see Table 2.3). An old-fashioned teletype machine is operated at 110 baud. Modern terminals and personal computers generally use communication rates of 300 to 1200 baud, and 2400 and 4800 baud rates are becoming more common. Communication between mainframe computers generally travel over special lines that allow communication rates of 19,200 baud or more.

TABLE 2.3 : Some common baud rates

Baud rate	Typical usage
45.45	U.S. Government and Bell System 60 wpm
75	IBM Model 1050 (Optional)
110	Teletype Corporation Models 33, 35 Teletypes
134.5	IBM Models 2740, 2741, 1050 standard speed
150	Standard Computer Terminal
300	Standard Computer Terminal
600	Standard Computer Terminal
600	IBM System 1030
1200	Standard Computer Terminal
2400	Standard Computer Terminal
4800	Standard Computer Terminal
9600	Standard Computer Terminal

4. Digital and Analog Communication

There are two broad categories of data communication: digital and analog (see Table 2.4). Communication signals are either digital or analog. An analog signal consists of continuous but variable electrical waves. Digital signals are discrete electronic units transmitted in extremely rapid succession, similar to ultrafast telegraphy (see Figure 2.5). Telephone circuits and some specialised scientific equipment are analog; most computer-and computer-related equipment is digital.

TABLE 2.4 : Analog and digital Transmission

(a) Treatment of Signals

	Analog Transmission	Digital Transmission
Analog Signal	Is propagated through amplifiers; same treatment for both analog and digital data	Assumes digital data; at propagation points, data in analog signal is generated
Digital Signal	Not used	Repeaters retransmit new signal; same treatment for both analog and digital data

(b) Possible Combinations

	Analog Transmission	Digital Transmission
Analog Signal	Analog signal	Digital signal
Digital Signal	Analog signal	Digital signal Analog signal

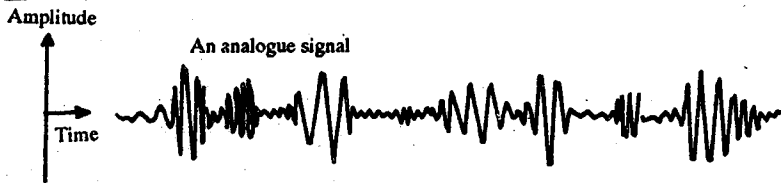
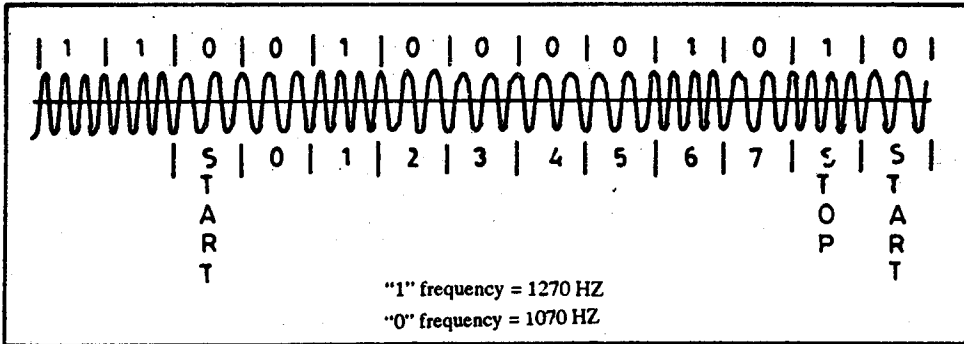


Fig. 2.5 a : Analog signal for "B" as transmitted by phone line

An analog signal can take on values from A continuous range of possible values over A length of time.

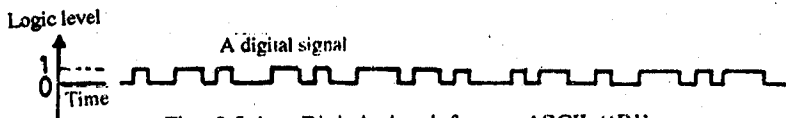
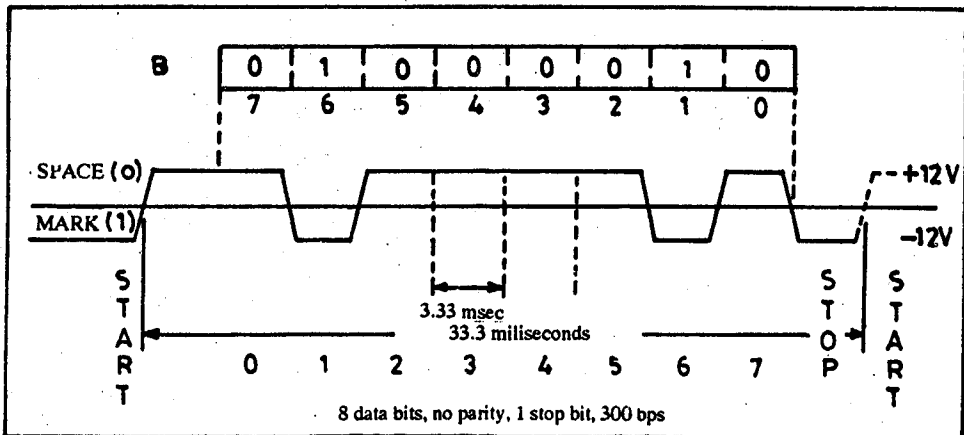


Fig. 2.5 b : Digital signal for an ASCII "B"

A digital signal can take on only a limited set of possible values (one of only two values for a binary signal) and transitions between these values occur raply.

Digital communication uses special equipment that transmits data directly in binary form, that is, as sequences of 0s and 1s. Analog communication uses general purpose communication channels, such as telephone lines. In order for computer data in binary form to be transmitted over these channels, the 0s and 1s must be translated into electrical signals compatible with the channel. This is usually done using a device called a modem (modulator-demodulator).

Since digital communication requires expensive equipment at both the sending and receiving ends, it is used almost exclusively for communication between mainframe computers. Communication involving personal computers is almost exclusively analog, with telephone lines serving as the communication channel and modems as the data communication devices (see Figure 2.6).

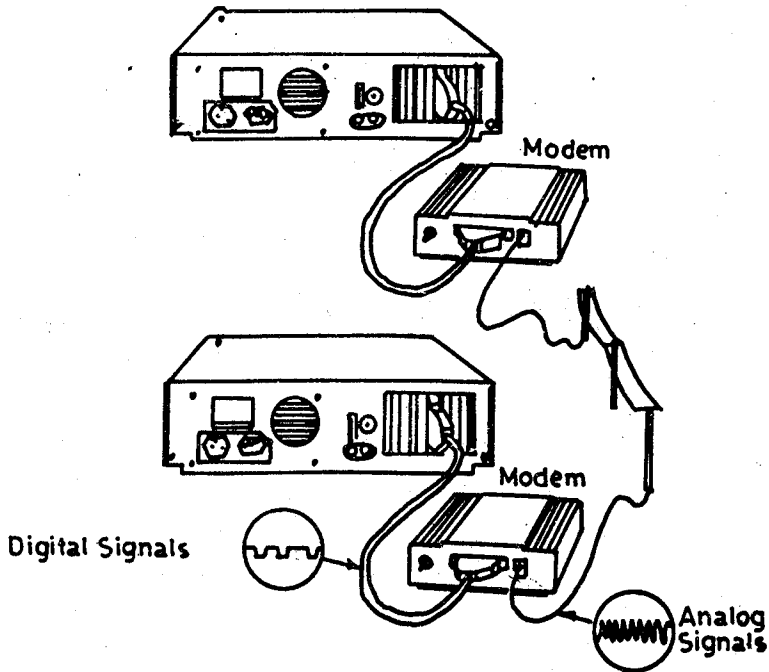


Fig. 2.6 : PC-to-PC connection via phone line

5. Parallel and Serial Communication

Most data are organised into 8-bit bytes. In some computers, data are further organised into multibyte words. Sometimes data are transmitted, a byte or a word at a time. This is done using many wires, with one wire carrying each bit (see Figure 2.7a). This is parallel communication. An alternative is serial communication, in which the bits are sent one after another in a series along the same wire (see Figure 2.7b).

Parallel communication is used primarily for transferring data between devices at the same site. For example, communication between a computer and a printer is most often parallel, so that an entire byte can be transferred in one operation. Communication between computers is almost always serial (see Figure 2.8).

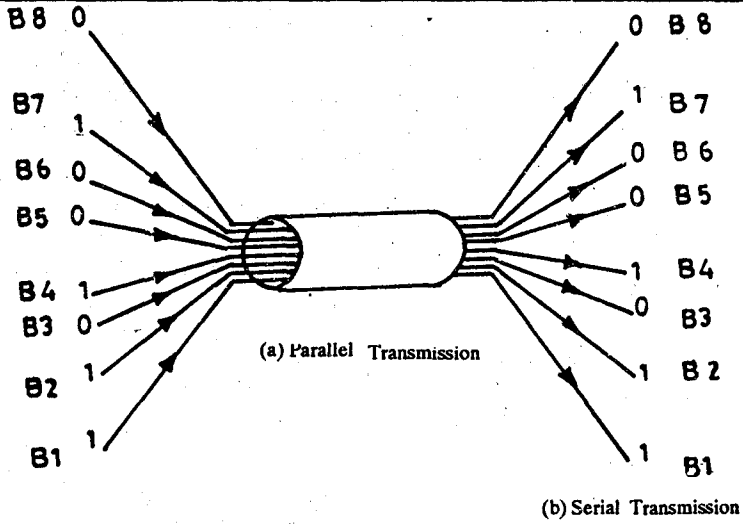


Fig. 2.7 a : Parallel and Serial Communication



Fig. 2.7 b : Serial Transmission

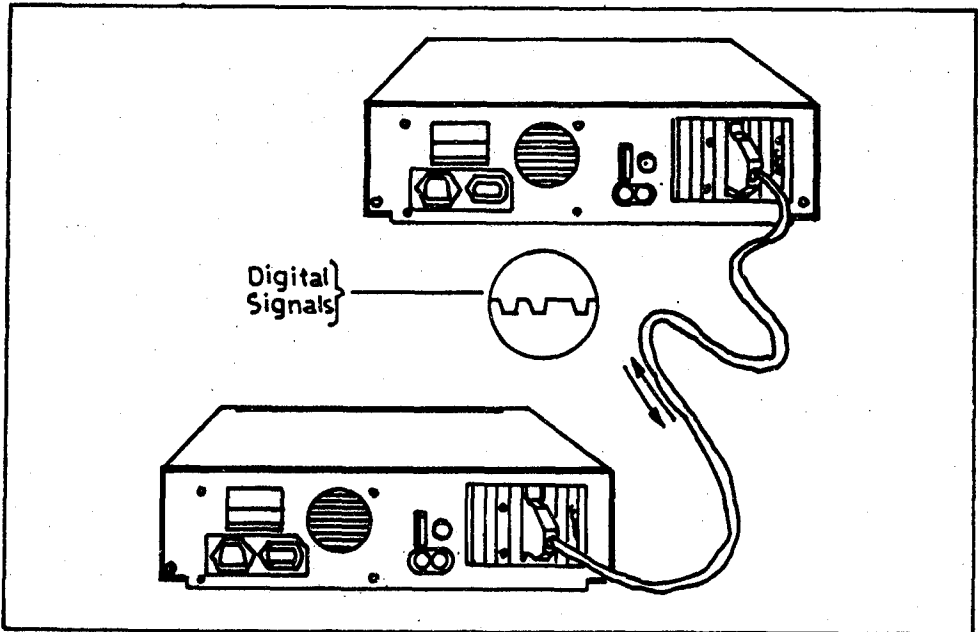


Fig. 2.8 : Direct serial connection between two computers

6. Synchronous and Asynchronous Communication

The mode of transmission is the way in which the coded characters are assembled for the process of transmission and permits the receiving devices to identify where

the coding for each character begins and ends within the torrent of bits. When two computers communicate, they must have a way to synchronise the flow of data so that the receiving computer can read at the same speed at which the sending computer transmits. The principal modes are asynchronous and synchronous. Bisynchronous is a variation of the synchronous mode used frequently in data communications.

In synchronous transmission characters are transmitted as groups, preceded and followed by control characters. The transmission and receiving intervals between each bit are precisely timed permitting grouping of bits into identifiable characters. In synchronous communication, data bytes are sent one after the other at regular intervals. The data form a continuous stream of bits spaced at equal intervals, with no space between consecutive bytes. A timing mechanism causes the receiving modem to read the stream at precisely the correct frequency (see Figure 2.9a). When the receiving modem has read the required number of bits to make up a character, it sends the character to the receiving computer.

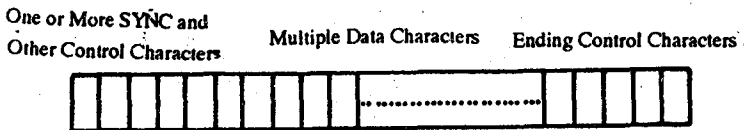
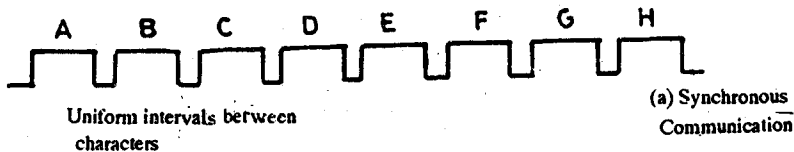
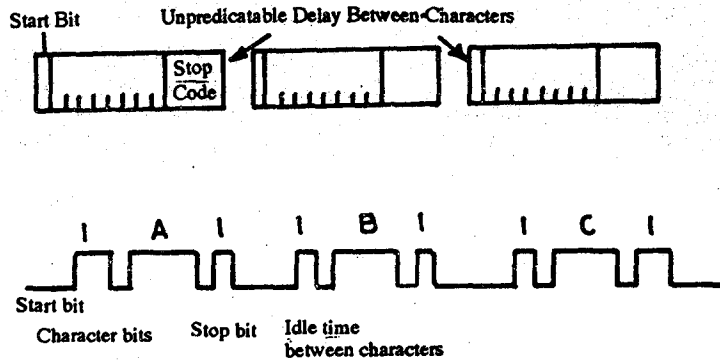


Fig. 2.9 a : Synchronous Communication

Synchronous transmission occurs mainly between computers but is also used for human operation of buffered terminals, that is, terminals that can store information. Its chief advantage is speed, since fewer bits are needed to identify the beginning and end of the character coding. Its chief drawback is inaccuracy: when a receiver goes out of synchronisation, losing track of where individual characters begin and end, correction of errors takes additional time. Synchronous communication requires high-quality communication channels, since there is no room for error. Conditions such as static on the line can cause the bits to be misread. High-quality channels are usually used for high speed data transfer, typically at more than 2400 baud.

In asynchronous transmission each character is transmitted separately, that is, one character at a time. The character is preceded by a start bit, which tells the receiving device where the character coding begins, and is followed by a stop bit, which tells the receiving device where the character coding ends, after which there is an interval of idle time on the channel (see Figure 2.9b). Then the next character is sent, start bits first, character bits next, stop bits last. The start and stop bits (and the interval of time between consecutive characters) allow the receiving and sending computers to synchronise the transmission. This is the most common mode worldwide, especially



(b) A synchronous Communication

Fig. 2.9 b : Asynchronous Communication

for operation of interactive computer terminals and teletypewriters. Its principal advantage is accuracy. Its main drawback is slow transmission time, caused by the great number of start and stop bits.

Asynchronous communication is slower than synchronous communication; it is typically used at communication rates lower than 2400 baud. Asynchronous communication, however, does not require the complex and costly hardware required for synchronous communication and is, therefore, the method used almost exclusively with microcomputers.

One exotic mode, called isochronous, involves synchronous transmission of asynchronous format.

7. Protocols and Buffers

Protocols are technical customs or guidelines that govern the exchange of signal transmission and reception between equipments (see Figures 2.10a and 2.10b). Each protocol specifies the exact order in which signals will be transferred, what signal will indicate that the opposite device has completed its transfer, and so forth. Both hardware and software are designed to handle specific protocols, and protocols are often named for the device with which they are associated. Teletypewriters (TTYs), for example, use TTY protocol. Only devices using the same protocols can communicate directly with one another. Devices using dissimilar protocols must transmit and receive through an intermediate interpretation device or programme.

Data communication between computers takes place independently of the CPU through the use of buffers at both the receiving and sending ends. A buffer is a section of RAM that holds data being transmitted or received. When the sending computer's buffer is almost empty, the CPU is interrupted and asked to refill the buffer. At the receiving end, the receiving buffer interrupts the CPU when it is full, and the data are moved to their ultimate destination (screen, printer or disk).

If the buffer size is large or the communication rate slow, the buffer may be manipulated without interrupting the transmission of data. If the buffer size is small or the communication rate high, the sending and receiving modems use a protocol,

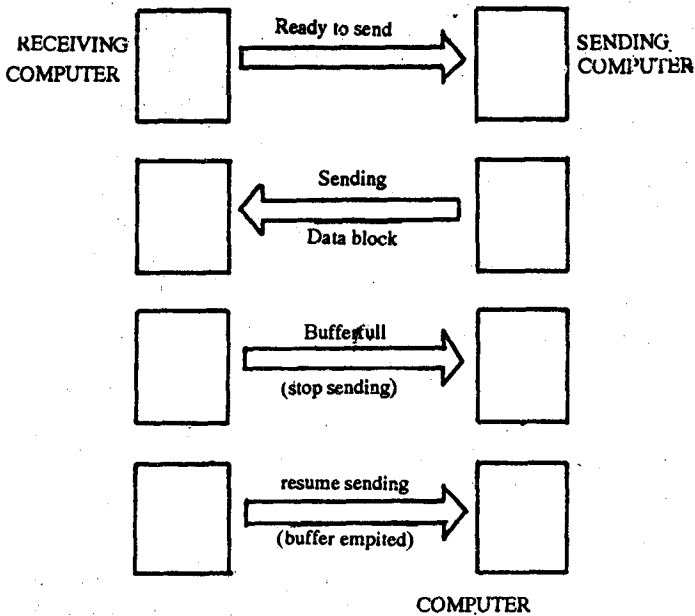


Fig. 2.10 a : The use of protocols

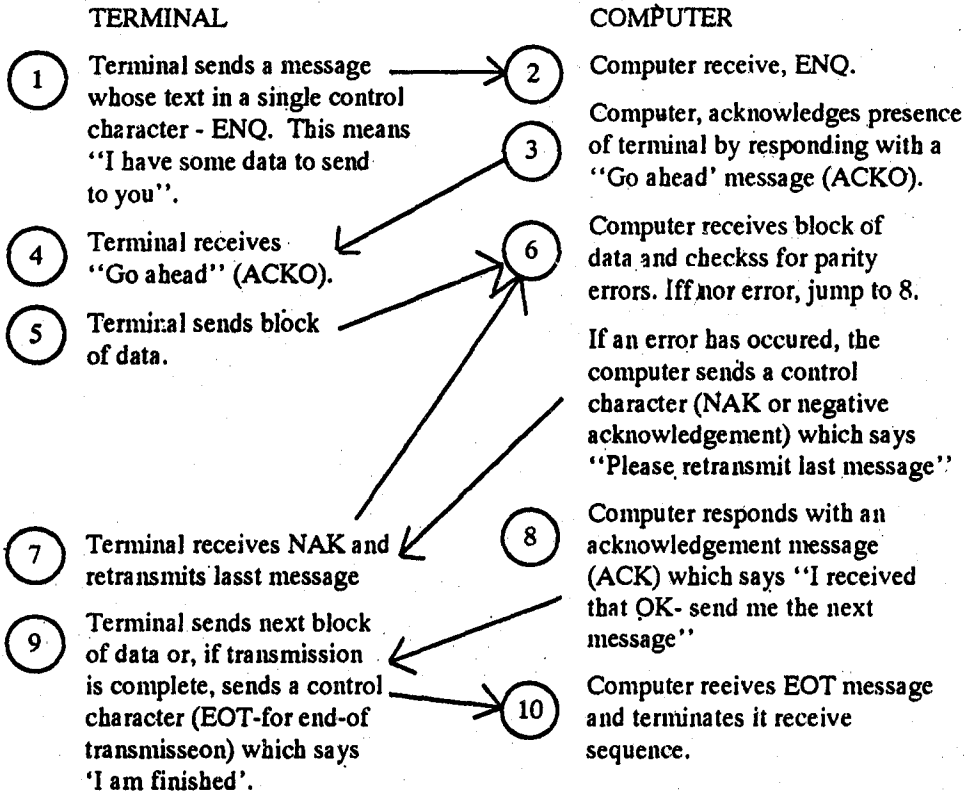


Fig. 2.10 b : Data transmission using Bisynch

or prearranged sequence of signals, to interrupt the transmission while the buffer is filled or emptied. When the receiving computer's buffer is full, the receiving modem sends one signal to tell the sending computer to stop. When the buffer has been emptied, the receiving modem sends another signal to tell the sending computer to resume sending (see Figure 2.10a).

8. Detecting Errors

A number of methods are used to detect errors in transmitted data. The most common method is inserting a parity bit alongside data bits for a character. If the receiving modem detects an incorrect parity bit, it can ask the sending modem to retransmit the character (see Figures 2.11a and 2.11b).

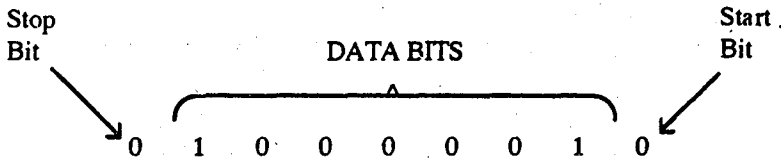


Fig. 2.11 a : String of data with start and stop bits

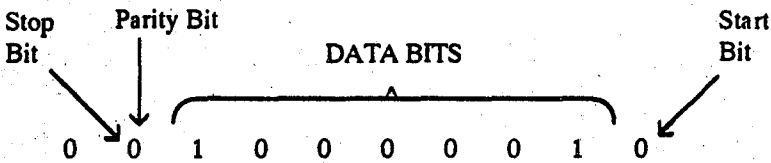


Fig. 2.11 b : String of data with parity bit added.

9. Simplex, Half-Duplex and Full-Duplex Communication

There are three distinct modes in which a communication channel may be used: simplex, half-duplex and full-duplex.

In simplex mode, the communication channel is used in one direction only (see Figure 2.12a). The receiver can listen to the sender but cannot talk back. Since the use of protocols and the detection of errors require two-way communication, the simplex mode is rarely used for data communication.

In half-duplex mode, the communication channel is used in both directions, but only in one direction at a time (see Figure 2.12b). The use of a half-duplex communication channel is similar to the use of a citizens' band (CB) radio. Only one party can speak at a time. When the speaker is done, he says, 'Over', and the other party begins to speak. Some time is lost in changing the direction of speaking on a CB. The same is true on a half-duplex communication channel. It takes from 1/20 to 1/4 second to change the direction of transmission. If many changes take place, the communication rate is slowed appreciably.

In full-duplex mode, the communication channel is used in both directions at once (see Figure 2.12c). The use of a full-duplex communication channel is similar

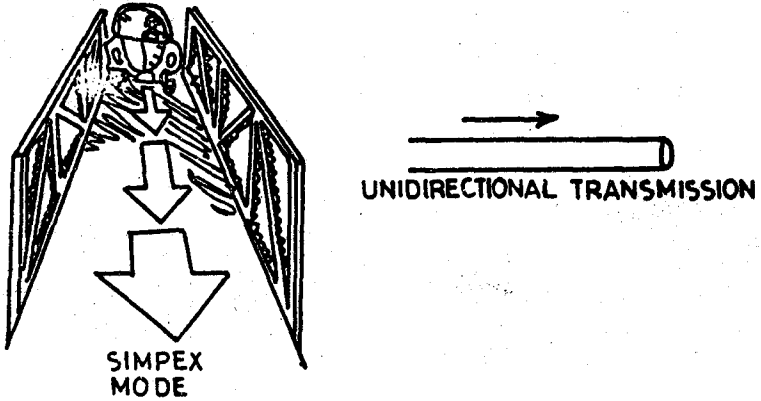


Fig. 2.12 a : Simplex, Half-duplex, and Full-duplex modes

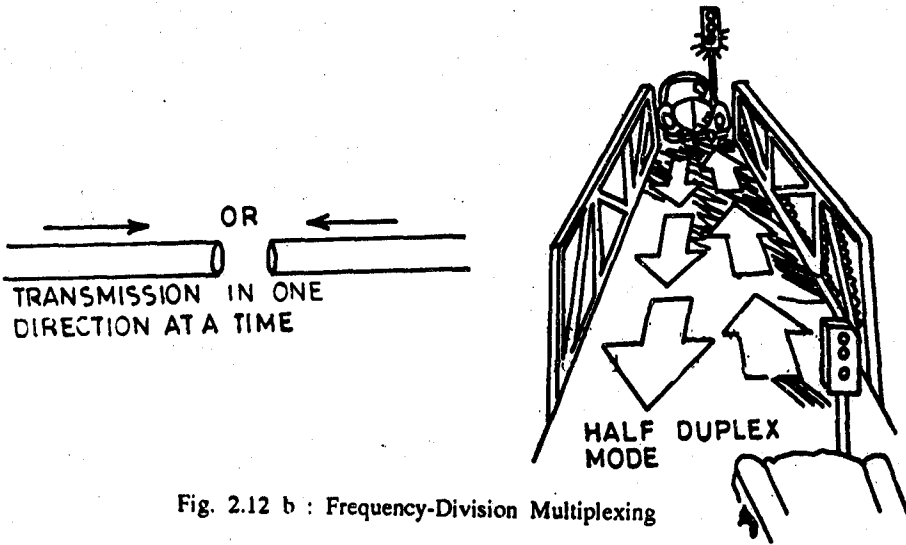


Fig. 2.12 b : Frequency-Division Multiplexing

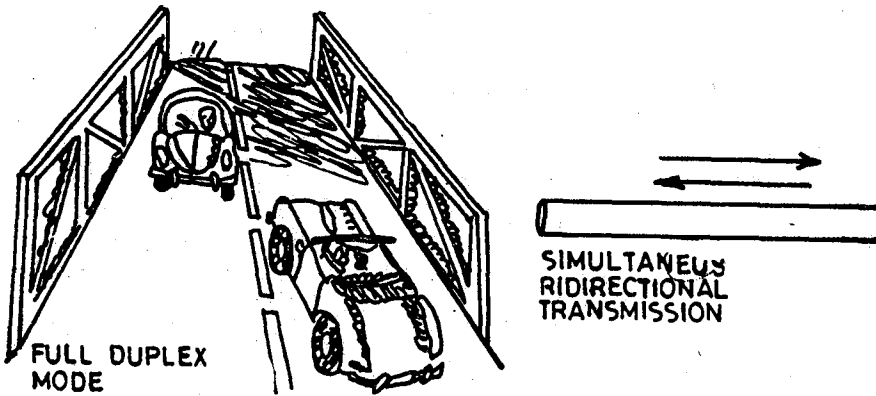


Fig. 2.12 c : Time-Division Multiplexing

to the use of a telephone, in that both parties are allowed to speak at the same time. The difference is that both computers connected by a full-duplex channel can hear and understand what the other says. The full-duplex mode is used for high-speed data communication between mainframe computers where the use of the half-duplex mode would seriously lower the communication rate.

10. Multiplexing

Multiplexing is a form of data transmission in which one communication channel carries several transmissions at the same time. The telephone lines that carry our daily conversations can carry thousands or even more of conversations at a time using multiplexing. The exact number of simultaneous transmissions depends on the type of communication channel and the communication rates.

User seldom needs to tax the full capacity of a transmission system, resulting in inefficient utilisation. On the other hand, a user sometimes needs limited amounts of both narrowband transmission and lower-range broadband for high-speed data transmission. Several devices subdivide wideband circuits into multiple narrowbands and link other circuits electronically to resemble wideband circuits.

Multiplexers, nicknamed "muxes", permit a single transmission link to perform as if it were several separate links. A frequency-division multiplexer (FDM) divides the actual bandwidth into smaller units of frequency and assigns each to a specific device (see Figure 2.13a). Each device sharing the circuit communicates on its individually assigned frequency as if it had its own dedicated circuit. Frequency-division multiplexing works best with low-speed devices. A time-division multiplexer (TDM) apportions very small segments of time in the bandwidth to each device, then polls each in sequence and permits it to communicate (see Figure 2.13b). The polling occurs so quickly that each device seems to have a separate circuit.

Concentrators operate synchronously and offer the functions of a multiplexer but can also store groups of characters, convert formats, check for errors and perform other functions.

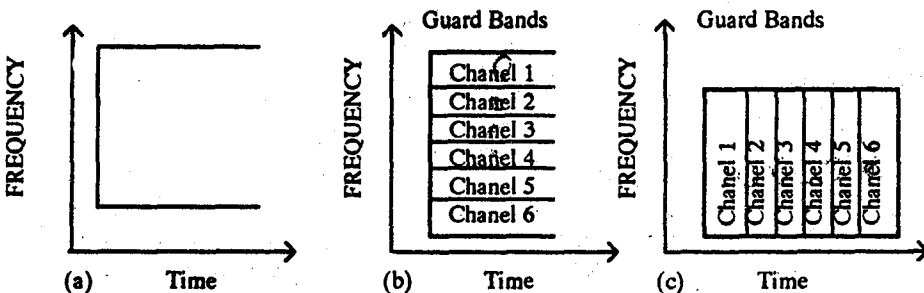


Fig 2.13 a : A telecommunication channel can be represented by its bandwidth available over a length of time. The telecommunication channel of (a) can be fully utilized in one of two ways : (1) By subdividing it into narrower frequency bands, or channels to (b).

(2) By allocating its full bandwidth to a set of channel in term IC (c).

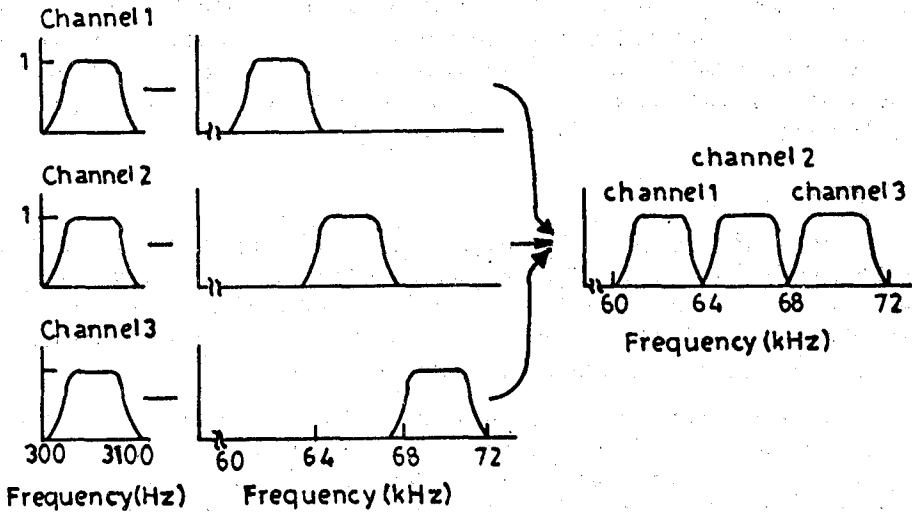


Fig. 2.13 b : Frequency-division multiplexing. (a) The original bandwidths. (b) The bandwidths raised in frequency. (c) The multiplexed channel

A statistical multiplexer is a hybrid of an FDM, TDM and concentrator. Although a terminal or computer is intermittently inactive during interactive transmission, a TDM continues to offer it time regardless of need. An FDM likewise apportions a small portion of the bandwidth to each terminal regardless of need. But statistical multiplexer will bypass a momentarily inactive terminal and give the bandwidth to an active one. If the volume of traffic from all the devices exceeds the capacity of the circuit, the statistical multiplexer will store the traffic until circuit time is available.

Some devices can combine two or more channels into a wider one by fragmenting data transmissions into segments of equal size and sending alternate segments down alternate physical links, then, at the receiving end, collate the signals before transferring them to the ultimate receiving device. A bplexer, for example, can link two 9.6 kilobaud circuits so that the devices communicating through the bplexer will view the circuit as 19.2 kilobauds in band width.

COMMUNICATION HARDWARE

In this section, we concentrate on communication between a microcomputer and either another microcomputer or a large computer, discussing the hardware on the microcomputer side first. Almost all communication involving a microcomputer uses a telephone line as the communication channel. The transmission is asynchronous and usually half-duplex. The microcomputer is connected to the telephone line by two devices: a communication adapter and a modem.

Communication Adapter

Bits flow between computers in one of two ways. The most common method

sends bits in a continuous stream, like a string of boxcars riding a rail-road track. This type of data transmission is termed serial because bits flow in a series. The other prevalent variety of data transmission is referred to as parallel. In this method, each of the eight bits that make up a character travels down a separate wire simultaneously. While parallel data flow is impractical for communication over telephone lines, it is the predominant way of linking computers to printers.

To communicate with the outside world, your PC must have an external serial connector, usually located on the end of a plug-in board. The three most common names for this connector are serial port, RS-232C connector/interface and asynchronous communication port/adaptor.

These terms are less slippery than they first appear. Port, for example, merely refers to any connector on your computer that acts as a point of data entry or departure. RS-232C is the label assigned to a technical standard that specifies how each pin of a serial connector is wired and which pin fulfills what function. The term asynchronous means, in its broadest sense, that data is transferred in byte-size pieces, rather than in a continuous, synchronised stream of bits. Synchronous communication is common in the mainframe world, but most PC-to-PC communication falls into the asynchronous category.

A communication adaptor is a circuit board that handles the transfer of data between the computer and the telephone line. It reads and writes data to and from a buffer in RAM. It signals to the CPU when the buffer needs to be refilled or emptied. During transmission, it formats the data, adds start bits, stop bits and parity bits, and controls the communication rate. When it receives data, it strips away the start bits, stop bits and parity bits and signals the sending computer to transmit the next character.

The communication adaptor may be built into the computer, or it may be an optional circuit board. The communication adaptor connects to the outside world via a 25-pin connector. The signals carried by each of the pins is defined by an internationally agreed-upon standard. For example, one pin carries a signal that, if present, indicates that the computer at the other end is ready to accept data; another pin carries the actual data; and so on for each of the other 23 pins. A cable plugs into the 25-pin connector and carries the signals to the modem.

If you use a special cable to connect one computer directly to another via their serial ports, the signals going through the cable are the same digital pulses that flow within the computers themselves. This "null modem connection" is the purest possible method of communicating data from one computer to another. There is little chance of error creeping in, provided the cable is not too long.

Acoustic Couplers and Modems

Digital transmission via an analog circuit requires the use of acoustic couplers or modems to resolve incompatibility. Communicating with a computer over the telephone lines is a different story from establishing a simple cable-connection. Because

telephone lines handle only audible signals, you cannot transmit digital pulses (see Figures 2.14a and 2.14b).

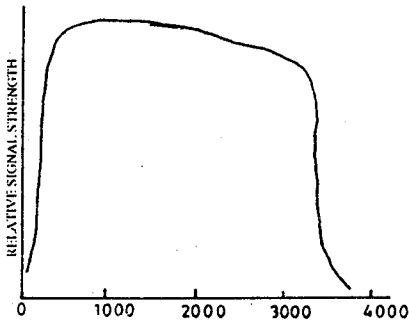


Fig. 2.14 a : Characteristic curve due to conditioning

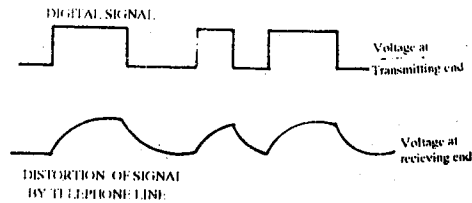
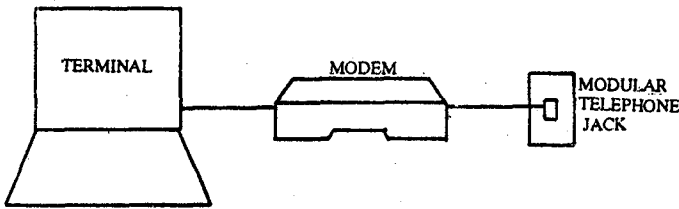


Fig. 2.14 b : Digital signal and its distortion

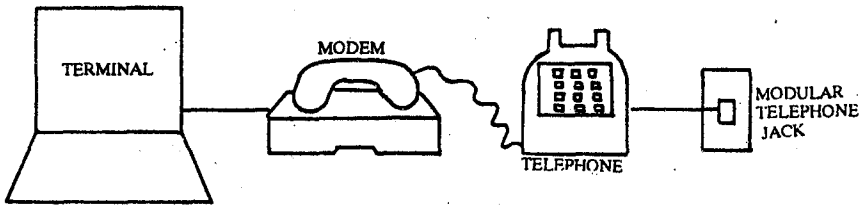
To send data you must modulate these pulses or convert them into sounds that represent high and low bits. At the receiving end, the audible signals need to be demodulated back into digital pulse form. This MODulation and DEModulation is performed by the aptly named modem. Modem is used to convert data from digital form into a form that can be transmitted or read over a telephone line. The modem is connected to the communication adapter at one end and to a telephone line at the other. Modem directly convert signals from a computer or other digital device into analog form for transmission over analog links, and vice versa. They can operate at up to 9,600 baud (300/600/1200/2400/4800/9600 BPS) over voice-grade telephone lines, but slower speeds are more common. Three types of modems are available; one is acoustic, while the other two are direct-connect modems.

The designs and capabilities of modems are quite varied. Modems can be either external or internal. An external modem is a box that is separate from the computer and connected to the communication adapter by a cable. An internal modem is contained on a printed circuit card inside the computer and combines the communication adapter with the modem. It is connected either to a modular telephone wall jack or to the jack on a telephone instrument. An internal modem is very neat and convenient, but the type chosen depends on the model of the computer. On the other hand, an external modem can plug into the communication adapter of any computer.

A second difference in design is that the modem can be connected to the telephone line in one of two ways. The first way is through a direct connection, in which the modem, called a direct-connect modem, is connected directly to a telephone line through a modular jack (see Figure 2.15a). The second way is through an acoustical connection, in which the modem, called an acoustical modem, uses a telephone receiver to transmit signals. The modem is connected to an acoustical coupler that converts the data into



(A) A Direct-connect modem.



(B) Operation of an acoustical coupler

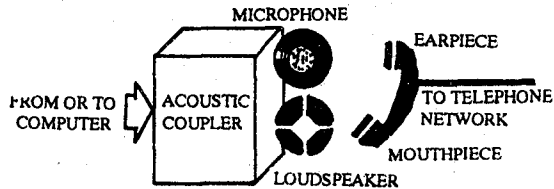


Fig. 2.15 : Modems - The use of
 (a) a direct - connect modem; and
 (b) an acoustical modem

audible signals. The telephone receiver rests in the cradle of the acoustical coupler, receives the audible signal and transmits the signal to the telephone line (see Figure 2.15b).

More likely, you will be using a direct-connect modem. Direct-connect modems for the PC come in two styles. One is a stand-alone modem, so called because it sits apart from the PC, connected by cable to the PC's serial port. The other type, referred to as an internal modem, is usually a plug-in expansion board but may be built-in at the factory, a common practice with laptop computers.

Both stand-alone/external and internal modems usually have two modular telephone jacks on their rear panels. One connects the modem to the telephone wall jack. You can plug your telephone in to the other and perform both voice and data communications over the same line.

An acoustic coupler is a small device with two openings that accommodate the earpiece and microphone ends of a telephone handset. The coupler converts outgoing

electronic signals from the digital device into analog sounds and transmits them to the microphone of the telephone handset; these then are ready for transmission into the telephone line. At the earpiece end of the receiving telephone, the coupler reconverts the analog sounds into digital electronic signals and transmits them to the attached digital device. Acoustic couplers operate at speeds of either 300 or 1,200 baud. Most acoustic couplers link telephones to computer terminals and facsimile machines.

Acoustic couplers cost little to rent or purchase and permit use of any standard telephone for transmission and receiving. However, because the telephone is connected acoustically instead of being wired to the computer or facsimile device, loud background noises can sometimes penetrate the acoustical seal and cause transmission errors.

Acoustic modems are easily recognised by their rubber cups, which hold a telephone handset. This kind of modem is rare these days, principally because it is relatively slow in transmitting and receiving data and because it lacks a number of automatic features that are now commonplace. Acoustical connections are less reliable than direct connections, as telephone receivers may be affected by external noise. An acoustical modem is limited to a communication rate of 300 baud, whereas direct-connect modems have communication rates up to 2400 baud. Both types of modems are in common use.

Unlike acoustic couplers, modems are wired directly to both the digital devices and the transmission line, which limits portability but keeps room noises from interfering with transmission and reception. Some modems have only a dial-out capability; another type, known as auto-answer, can be used for dialling out and can also automatically answer and connect calls to the local, parent device. Some modems of both types have telephones attached for normal call placing and receiving.

COMMUNICATION PROCEDURES

All communications between computers are managed by data communication software. The precise procedures used depend on the particular software, but the following account outlines the general procedures.

Communication Between Two Microcomputers

A small business that uses microcomputers has accumulated information that it wants to send to a customer who also uses microcomputers. The procedure used to send the information is as follows:

1. Both the business and the customer start the communication programme, which gives them a menu of options.
2. Both the business and the customer choose the same options, including the number of start and stop bits, the type of parity checking, the communication rate, full-duplex or half-duplex transmission, and so on.
3. The communication link is established. The users decide who will originate the telephone call, and the originator enters the telephone number. The communi-

electronic signals from the digital device into analog sounds and transmits them to the microphone of the telephone handset; these then are ready for transmission into the telephone line. At the earpiece end of the receiving telephone, the coupler reconverts the analog sounds into digital electronic signals and transmits them to the attached digital device. Acoustic couplers operate at speeds of either 300 or 1,200 baud. Most acoustic couplers link telephones to computer terminals and facsimile machines.

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3. The communication link is established. The users decide who will originate the telephone call, and the originator enters the telephone number. The communi-

cation programme then instructs the modem to dial the number and reports to the users if a connection has been made.

4. After the connection has been made, the users can have an on-line conversation. They can type messages back and forth to each other and can record their conversation.
5. When the business is ready to transfer the information, it sets its computer to send; the customer sets its computer to receive. The business starts the transfer. The communication programme takes over by reading the information from the disk and sending it through the communication link. The receiving computer stores the incoming information on a disk. The transfer proceeds without any further human attention.
6. When the transfer has been completed, the business and the customer say "goodbye" and terminate the connection.

Communication Between a Microcomputer and a Larger Computer

The procedure for communication between a microcomputer and a minicomputer or mainframe is similar. One difference is that the larger computers have safeguards that limit access to files and facilities to authorised users. The most common safeguards are the user identification number and the user password.

After the communication link has been established, the receiving computer asks for the user's identification number. This number is assigned to the microcomputer user by the operators of the larger computer. When requested to do so, the microcomputer user types in the user identification number. The receiving computer checks that the identification number is valid. It then asks for the user's password. A password is a confidential sequence of characters that allows access to the system. An example of a password is:

S17K64B#

The password is required for the user to obtain access to the larger computer. It also determines exactly which files and facilities the microcomputer user is allowed to read. If the typed password is valid, the microcomputer user is allowed access to the large system.

Front-End Processors

Keeping track of communication activities is a complex data processing task. In the case of high speed data communication between two mainframes, such "housekeeping" can occupy 20 to 25 percent of the processing time of the CPU. To alleviate this problem, some data communication tasks are often given to a mini or microcomputer. Such a computer is called a front-end processor and sits between the main computer and the modem (see Figure 2.16). The front-end processor typically performs the data formatting and checking activities that would be handled by the communication adapter of a microcomputer.

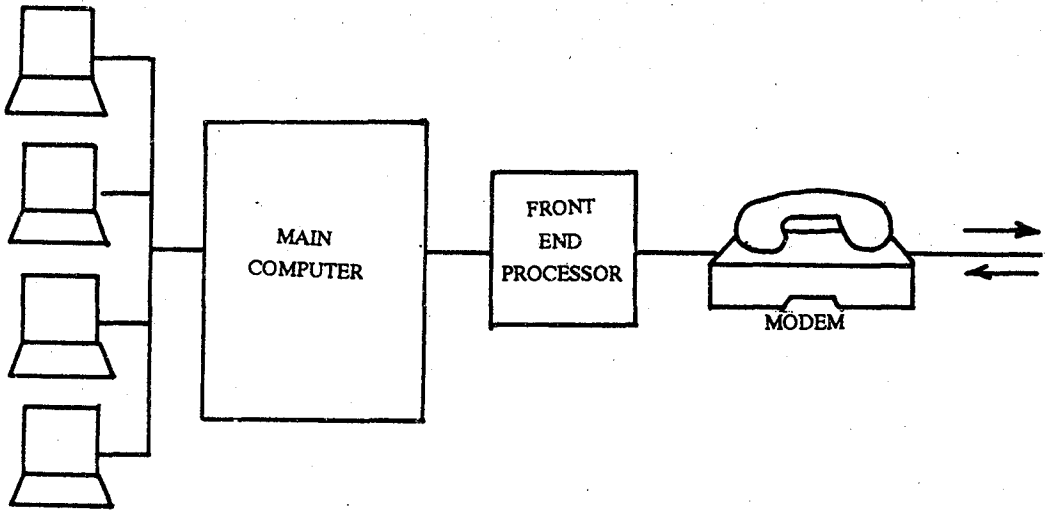


Fig. 2.16 : Front-end processors. Front-end processors are computers that handle communication processing to lift the burden from the main computer

Going On-Line

Before you establish a communication link, you must adjust various settings to match those of the computer you want to connect with. Called communication parameters, these settings vary with different types of computers and programmes. Fortunately, most communication programmes let you store and retrieve the parameters that apply to various remote systems.

When you connect to a remote system such as an on-line information service, you will probably be asked to reply to one or more on-screen questions. Generally, you will need to provide some kind of identification, such as your name, an account number and a password. This brief dialogue between you and the remote system is often called a logon procedure.

Some remote systems compare your identification with a list of paid subscribers. Obviously, if you are not on the list, you would not be able to access the service. Other systems use the logon procedure as a security measure, protecting valuable records from tampering. In either case, the remote system maintains a record or log of every caller.

Many communication programmes support automated logon procedures. When you log on for the first time, the programme "records" your entries for later use. Subsequently, when you access the remote system, these entries are automatically supplied in response to prompts from the remote system. Many communication software packages let you dial, connect and log on to a remote system at the touch of a single function key.

Once you have gone through the formalities, the remote system usually welcomes you with a greeting and waits for your next command. At this point, your communication software has turned your computer into a simple video terminal, allowing you to use the remote system's software as if you were connected directly to the system.

File Transfer

Transferring files to and from your disk drive is one of the most common communication applications. These files may be bulletins, electronic mail messages, airline information or even computer programmes.

In addition to matching communication parameters, file transfer requires that both systems in a communication link agree on a common protocol. A protocol consists of the technical details that regulate data transmission between computers. Fortunately, you need only a rough idea of how a protocol works in order to use one.

The simplest to understand is the text or ASCII protocol. This method sends a file as one uninterrupted stream of ASCII characters. While this protocol offers transmission of maximum characters in the shortest possible time, it is also the one most likely to produce errors, especially over noisy telephone lines.

To combat flaws in file transfer, most protocols offer error correction. Specific methods vary from protocol to protocol, but the basic error correction scheme is the same: breaking up a file into small blocks and then comparing the received blocks to those that were sent to make sure they are identical. Each block includes an extra character mathematically derived from the ASCII values of the characters it contains. If the receiving computer comes up with a different value for that character after it receives a block, it assumes an error has occurred and requests that block again. While this procedure reduces throughput, error checking and correction virtually assure error-free file transfer. Common error-correction programmes now include more advanced session level protocols that check for errors throughout an entire communication session, not just during file transfer.

Choosing Parameters

Before logging on, you must make sure that you and the remote system are using the same communication parameters — the various settings that regulate the means of communication. To clarify this point, baud rate, parity, stop bits and echo are further discussed.

Baud rate refers to the rate or "speed" of data transfer. In common parlance, this means the number of bits per second (bps) sent or received. Technically, baud rate refers to the rate of the phase-shifting method a modem uses to transmit information - which is not necessarily the same as the bps rate. However, most modem manufacturers use baud rate to describe bps, and this corruption of the technical term is now commonplace. Since transmitting one character usually takes 10 bits, dividing the baud rate by 10 will give you a rough approximation of how many characters per second are being transferred.

Which baud rate you use depends on the capabilities of your modem, as well as the equipment used by the remote system. Most modems for personal computers transfer data at 300, 1200 or 2400 baud. Whatever baud rate your modem supports, it has to be seen that the rate for your modem and the remote system must be identical.

Sometimes a remote system will have different phone access numbers for different baud rates. In general, you should communicate at the highest baud rate possible, since this reduces the amount of connect time you are charged for. However, some commercial information systems charge premium rates for communication at higher baud rates. Even so, the time saved makes using higher baud rates more economical when transferring large files.

Parity refers to a scheme using a single bit along with each character to test for accurate data transfer. The most popular configuration for PC communications uses seven bits for data and the eighth bit for even parity. Using even parity during data transfer means that the eight bit always makes the 1 and 0 bits within a character add up to an even number. If the receiving computer detects an odd number, it either requests retransmission or ignores the character completely. Sometimes, however, eight bits are used for data and an additional bit is used for parity, resulting in another common setting: eight bits and no parity. Other parity schemes, such as odd number, space, and mark are also used, but they are rather uncommon in PC communications.

Here are four examples of even parity:

<u>Memory byte</u>	<u>Parity (even)</u>
00000000	0
00000001	1
00000011	0
01000001	0

Stop bits refer to the variable number of bits used to mark the end of each character transferred. Often, you may see parity, the number of data bits and the number of stop bits in one reference.

"E-7-1," for example, means even parity, seven data bits and one stop bit. One stop bit is used almost universally in personal computer communication, and many communication programmes automatically use this setting unless you specify otherwise.

Echo refers to a remote system's practice of sending back the characters you transmit, giving you on-screen verification that the characters have been received. Mainframe computers and commercial information services often use this procedure, while most PC link-ups omit echo.

When you are on-line, it is easy to determine whether to turn the echo function on or off. If you see no characters on the screen as you type, turn echo on; if the characters you type appear in duplicate, turn echo off. Most communication programmes let you adjust the echo setting while you are engaged in a communication session.

Logging Off

When you have finished a session with a remote system, you need to formally log off. Usually, the system displays a message on screen confirming that log off procedures have been properly completed. Standard log off commands include log out, Bye, Quit, Off and Exit. If you disconnect without formally logging off the system, the remote system may be fooled into believing you are still connected. When you are using a commercial service that charges by the minute for connect time, this can be quite an expensive mistake. Therefore, it is a good idea to watch for the remote system's log off confirmation on screen.

COMMUNICATION PROCESSING

Communication processing is the collective term for all the activities that help ensure the successful entry, transmission and delivery of information. Just as data processing involves taking raw data and adding value by changing the inherent information content, communication processing adds value to the raw message by insuring that the message arrives at its destination in a timely manner, in the proper form, at the proper speed, in the proper language and without errors.

The basic responsibilities of communication processing can be divided into three major areas: editorial, conversion and arbitration. Editorial functions include formatting of the message, editing the data and controlling errors. Conversion functions include translating transmission speed and code. Arbitration functions involve network control and message routing.

Communication processing can be performed in any intelligent device, using the storage and processing capabilities of that device. In the microcomputer based LAN, most communication processing occurs within the microcomputer itself.

Within a network, communication processing is implemented as protocols, the rules that govern the transmission of information.

The following are sample communication processing services:

- Accommodating differing video display characteristics such as screen size, line strength and paging.
- Translating data into the standard network format and subsequently retranslating the data to meet the requirements of the receiving station.
- Controlling the sequence in which messages are sent.
- Assembling and transmitting messages on the basis of time interval, order received, receipt of particular character or other characteristics.
- Alerting users to error conditions and possible problems.

Packets

It is neither practical nor advantageous to transmit long messages as a single entity. Therefore, for the purpose of data transmission, particularly in local area

networks, messages are broken down into segments, called packets. As shown in Figure 2.17, each packet normally contains five parts:

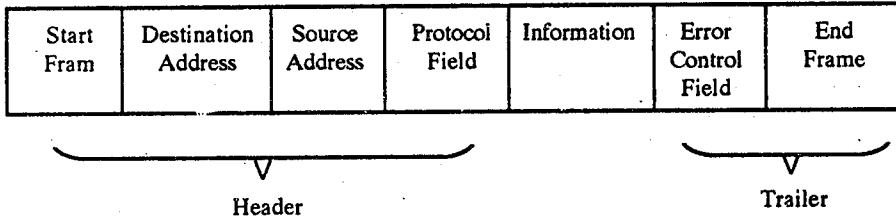


Fig. 2.17 : Packet

- A start frame, identifying the beginning of the packet.
- A header, containing information for maintaining control of the packet and the network.
- An information field, containing a segment of the total text information or data to be communicated.
- An error control field, permitting the system to verify packet integrity.
- An end frame, signifying the end of the packet.

The control information contained in the header includes the source address, which identifies where the packet originated; the destination address, to which the segment is to be delivered; the packet sequence number, which helps insure that the packets can be reassembled in proper order; and a control block, which helps prevent duplication, loss or looping (in which a packet is routed back and forth in an endless circle) of the packet. Additional information to insure proper operation of the network under various overload or impaired operating conditions also may be included. Figure 2.18 further dissects the address fields.

What's in an Address ?		
Destination Address :		
Name	-	What workstation/resource is being sought ?
Address	-	Where is it ?
Route	-	How to get there.
Source Address :		
Name	-	Who sent the message ?
Address	-	Where is it ?
Route	-	Has to send a reply

Fig. 2.18 : What's in an Address

Overhead is the additional information that must be transmitted through the network in order to facilitate the proper transmission and delivery of messages. It is created by the system's need to maintain control of all transactions. A percentage of overall network capacity is dedicated to this control information.

Overhead information exists on the network in two basic forms: data appended to each user packet, such as the control, and error-checking fields named above. The

amount of data appended to a basic message varies from one system to another, and inself-contained acknowledgement and control packets, which are transmitted from one device to another. These packets keep the system advised of the status of the components.

COMMUNICATION CHANNELS

Besides telephone lines being used as communication channels, there are a number of other types of communication channels, representing both the wide range of possible uses of data communication and the various new technologies in the communication industry.

1. Wired Transmission

Transmission media are the electronic roadways along which signals are transferred. They range from telephone circuitry to laser beams and fibre optics (see Table 2.5).

TABLE 2.5 : Transmission media tools, capabilities, application, cost and security

Medium	Application	Narrowband	Broadband	Range	Cost	Security	Other factors
Hard-wiring	Telephone and narrowband local networks	X		Local	Low	Low	Simplicity
Coaxial cable	Long-distance telephone calls		X	Unlimited with	Local: low Long distance : high	Moderate	Compactness and versatility
Microwave	Local area and		X	25 miles (more relay stations)	Moderate	Moderate	Line-of-sight:
Infrared	Local networks	X		Several hundred feet	Low to moderate	Moderate	Line-of-sight: affected by weather
Laser	Local and are networks		X	3-15 miles	Low to moderate	Moderate	Line-of-sight
Satellite	Video Telephones High-speed fax Teletypewriter		X	7000-8000 terrestrial miles	High to very high	High with encoder	Line-of-sight: "echo" affected by weather
Radio :							
Class A	Area voice communication (commercial)	X		10 miles	Low	Low	License; no data trans.; assigned channels
Class D	Area voice communication (citizens band)	X		10 miles	Low	None	License; no data trans.; 40 unassigned channels

One of the most common transmission methods is termed hardwired, which means that two or more devices are connected directly by wiring. A twisted pair means that the connection uses two wires, sometimes in the same cord (see Figure 2.19). A twisted pair handles narrowband transmissions. Coaxial cable also uses two wires, but one is a tube woven from very fine strands of metal; the second wire passes through the centre along the length of the first (see Figure 2.20). It is used for long-distance service by telephone companies and for both baseband and broadband transmission in local area networks.

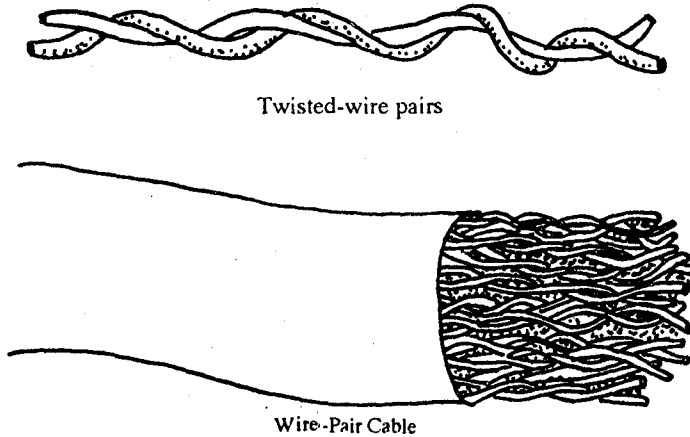


Fig 2.19 : Twisted-wire pairs

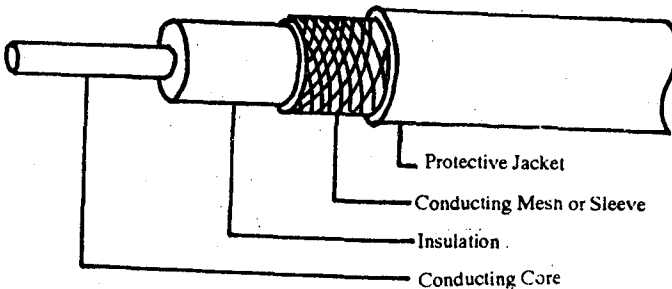


Fig. 2.20 : Coaxial cable

Twisted-Pair Wiring Characteristics:

1. Inexpensive
2. Easy to install
3. Easy to tap
4. Low noise immunity
5. Speed of up to 4 Mbps
6. Can accommodate up to 1,000 devices

7. Adequate for network span up to 1/2 mile.

Coaxial Cable Characteristics:

1. Widely available
2. Good noise immunity, high usable bandwidth
3. Speed up to 10 Mbps
4. More difficult to tap than twisted-pair wiring
5. More expensive than twisted-pair wiring.

Direct distance dialling (DDD) is the standard, voice-grade telephone service that provides direct dialling to other telephones without operator intervention. Such circuits accommodate narrowband analog transmission between 300 and 3,400 hertz or a maximum of 10,000 bits per second. A user can obtain similar circuits with the same bandwidth on a dedicated basis but only for access between the devices to which the circuit is connected, such as between a terminal in one city and a computer in another. Telephone companies also provide broadband analog and digital circuits to accommodate special needs. Digital circuits for data transmission eliminate the need for acoustic couplers or modems.

Telephone Lines

Using modems, telephone lines may be used to transmit computer data. The lines themselves may be either leased or switched.

Leased Lines

A leased line is a telephone line that is leased for the express purpose of maintaining a communication channel between two computers. The line is not shared with any other users and is available at all times for data communication between the computers. A leased line is similar to a telephone connection that is always open. Both computers are always listening for a signal to start the communication (see Figure 2.21). Leased lines are used in computer networks where computers or terminals in the network must be in constant contact with one another. For example, leased lines are used in a network employing point-of-sale terminals, as the terminals must be in constant contact with the main computer.

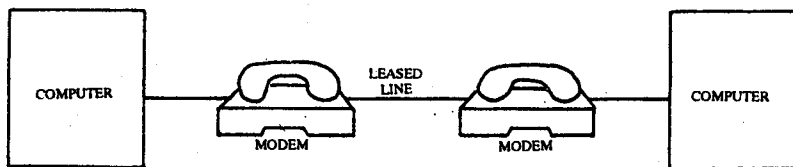


Fig. 2.21 : A Leased Line

Leased lines are often conditioned to limit the level of noise on the line. Conditioned leased lines are usually necessary to carry on high speed data communication. Security requirements often require that leased lines be shielded from outside interference and unauthorised snooping.

Switched Lines

A switched line can be used for either voice or data communication and is switched from user to user, as requirements dictate (see Figure 2.22). When switched lines are used, one computer must establish contact with the other by dialling a telephone number. After the transmission has been completed, the connection between the computers is broken, just as if a telephone receiver were hung up.

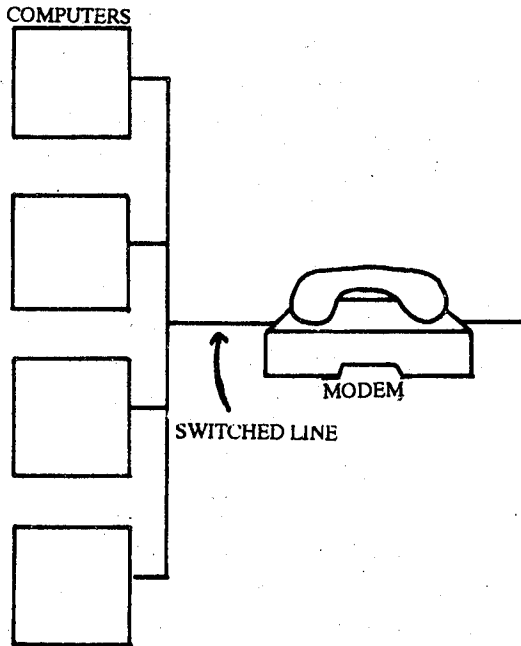


Fig. 2.22 : A Switched Line

Coaxial Cables

A coaxial cable consists of many small cables in a protective cover. The cover shields the cable from physical dangers as well as from electromagnetic interference. Within the cover, the various cables are shielded from interference with one another. Coaxial cables are used in communication networks that require many simultaneous communication links. Each coaxial cable can provide more than 5000 links.

There are two types of coaxial cables: baseband and broadband. A baseband coaxial cable transmits a single signal at a time at very high speed, while a broadband coaxial cable can transmit many simultaneous signals using different frequencies. A baseband cable transmits a single stream of digital data at a very high communication rate (millions of bits per second) but must be amplified every 1000 feet or so. It is

mainly used for local area networks. A broadband coaxial cable can carry only an analog signal, so it must be used in conjunction with a modem. It is more complex to use in a network.

2. Optical Fibre Transmission

Optical fibre systems consist of a transmitter, the glass fibre filaments along which data travel as high-speed pulses of light, and a receiver. Lighter, thinner and stronger than copper wire, optical fibres carry a great deal more data (see Figure 2.23). Further, they are impervious to electromagnetic interference and are highly secure: being optical in nature, they do not radiate electronic signals.

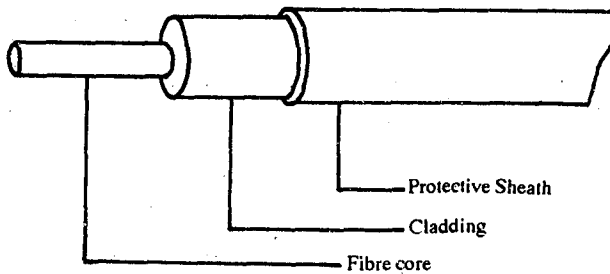


Fig. 2.23 : Optical fiber construction

A fibre-optic cable consists of strands of glass-like thread, each about the diameter of a human hair. Through the use of a laser, data are transmitted from one end of a cable to the other. Fibre optic cables will increase the capacity of like-sized coaxial cables by at least a factor of 10. This makes them valuable for use in a variety of applications, especially in communication networks. It is likely that they will eventually completely replace copper wire cables for communication applications.

3. Microwave Transmission

Microwave signals are similar to radio and television signals and are used to transmit data without the use of cables. Microwave signals are transmitted by antennas placed on local peaks, such as the tops of buildings or mountains. Microwave signals provide very high speed data transmission. However, their range of transmission is limited to about 30 miles as they use the upper atmosphere as a reflective surface. To transmit over longer distances, it is necessary to bounce the microwave signals through a chain of towers or to combine the microwave signals with some other communication channel (see Figure 2.24).

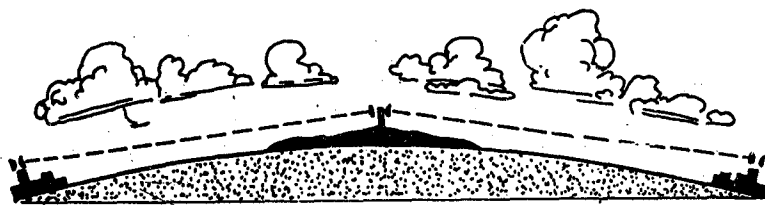


Fig. 2.24 : Microwave Transmission

Microwave transmission has become widely used for broadband communication and telephone service. Private microwave service is especially useful for organisations that need to link a number of locations within a limited area. Banks, for instance, often use it to connect suburban branch offices with city headquarters. Although private microwave service can provide dedicated communication at moderate cost, there are limitations to its use. First, microwave channels are generally assigned by the Federal Governments, and in some cities few or no channels remain open. Second, unlike telephone wires and commercial radio signals, microwave transmission is line-of-sight: the signals, which pass through the atmosphere, must originate from a dish antenna, travel in a straight line free of material obstacles such as topographical features or tall buildings, and be received by another dish antenna. Third, the transmission range is limited to about 25 miles (40 kilometres), after which the microwaves must be relayed (received, amplified and retransmitted by another antenna).

4. Infrared Transmission

Infrared transmission is optical in nature, carried by beams of light invisible to the naked eye. It provides a compact and inexpensive means of line-of-sight, narrowband transmission among and between buildings within the same general area, for it is limited to distances of a few hundred feet. Though unaffected by most artificial light and weather conditions, very heavy snow or fog degrades its quality. Infrared is not subject to governmental licensing since it operates outside the broadcast portion of the radio spectrum. It is moderately secure.

5. Laser Transmission

Communication laser are generally very low powered and narrowly focused beams of light, invisible to the naked eye, that rely on sensitive receiving equipment. The equipment is marketed in both narrowband and broadband versions. The usual line-of-sight transmission range of 15 miles can be greater or less depending on the percentage of operating time acceptable to the user. Repeater (relay) stations can increase the total transmission distance. Laser communication provides a high degree of inherent security.

6. Radio Transmission

Within the United States, the Federal Communications Commission has allocated certain radio frequencies for use by private businesses for direct voice communication. Word codes may be employed, but data transmission (or telemetry in radio parlance) is prohibited. Private citizens and business users may be licensed to operate either a Class A or D radio station, with a mobile or fixed location. The range of both classes is about 10 miles.

Users of Class A stations, such as taxicabs and delivery vehicles, operate only on a single, assigned frequency. Users of Class D stations, generally known as Citizens Band (CB) radio, operate on any of the 40 designated frequencies (channels) on a shared basis.

A mobile CB radio can be equipped with a special keypad and an unattended, fixed (stationery) CB with a matching device to make it possible for the user to dial into a telephone connected to the stationary radio. Once the circuit is completed, the person using the mobile CB radio can converse with the person answering the telephone call as if both were using a telephone. Owing to the special signalling requirements, the typical range between the mobile and base radio equipment is about three miles.

Security of such communication links is almost nonexistent. Even so, the equipment has many advantages and is widely used by taxi, repair, courier and delivery services.

7. Satellite Transmission

Both microwave signals and telephone signals can be relayed to an earth station for transmission to a communication satellite (see Figure 2.25). The earth station consists of a satellite dish that functions as an antenna and communication equipment to transmit and receive data from satellites passing overhead.

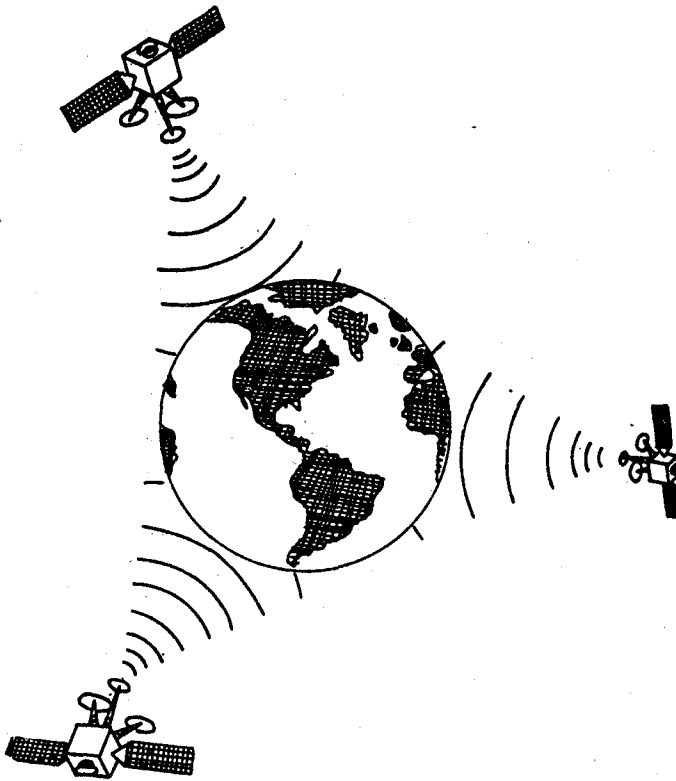


Fig. 2.25 a : Communication satellite in orbit 22,300 miles above the earth

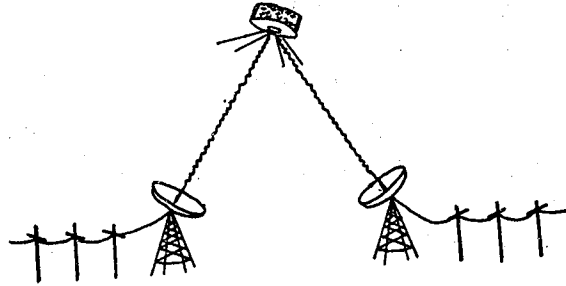


Fig. 2.25 b : Using a Communication satellite to relay communications
 Earth station : satellite antenna Earth station satellite antenna

A number of communication satellites, owned by both governments and private organisations, have been placed in stationery orbits about 22,300 miles above the earth's surface. These satellites act as relay stations for communication signals. The satellites accept data/signals transmitted from an earth station, amplify them and retransmit them to another earth station. Using such a set-up, data can be transmitted to the other side of the earth in only one step.

Most communication satellites have multiple, independent reception and transmission devices known as transponders. In a commercial communication satellite, a single transponder is usually capable of handling a full-colour, commercial television transmission, complete with audio. Transponders for data transmission may be even larger. Some firms that market satellite communication service own a satellite. Others lease a portion of a satellite and provide transmission facilities in smaller units to ultimate users. Some end-users transmit only voice communication during the working day and split their leased bandwidth (up to a full transponder) into many narrowband channels for that purpose. After office hours, these narrowband channels are electronically reorganised into fewer channels of wider bandwidth for high-speed data communication.

Several factors limit the use of satellite communication. Most communication satellites are placed in geosynchronous orbit above the equator, which means that their orbital speed is synchronised to keep them over the same point on the earth at all times. A satellite, then, is also a line-of-sight means of transmission. A second consideration is a signal delay caused by the extreme length of the transmission path between sender and receiver. This can cause an echo that is annoying to some individuals using voice communication, though the condition can be negated with electronic echo cancellers and suppressors. Other considerations are the weather sensitivity of high frequency transmission and electronic interference generally. Among the factors a prospective user must weigh is the relative importance of 20 to 40 hours of random reception difficulty per year.

Though some satellites can concentrate transmission signals to some degree, the area covered by those signals is still quite large, and anyone with the proper equipment can listen in. Security is usually provided by the user through coding and decoding equipment.

APPLICATIONS OF DATA COMMUNICATION

Many applications of data communication for computing fall into one of four categories: using external databases, sharing data, electronic mail and Bulletin Board Systems.

1. Using External Databases

One of the most important applications of data communication is the ability to access external databases. There are literally thousands of databases containing information on almost every conceivable subject. Users can subscribe to many of these databases at a cost of the initial fee and a charge for the amount of time spent accessing the database. Users can locate information in an index or can just browse through the database as they would browse through books at a public library.

The types of information available through services vary greatly, as can be seen in the following examples. The Dow Jones News Services provides current news, current stock and commodity prices, and securities research data. The stock prices are very nearly the same up-to-the-minute prices that are simultaneously crossing the tape at the major stock exchanges. This allows users to use the service for the data on which they base trading decisions.

A number of multiple-listing real estate services offer on-line options. This allows a broker to find all homes meeting particular criteria (price range, neighbourhood, size, and so on) to match client demands. Also in the real estate field, services supply on-line listings of currently available mortgage money, interest rates and restrictive terms. These services allow a prospective home buyer to shop the entire country to obtain the best mortgage terms.

A number of subscription services supply on-line transactions. For example, a number of banks now allow subscribers to bank through a communication link to a personal computer. Some services even allow users to pay bills in this way. Personal computers may also be used to execute stock trades through several on-line brokerage systems. Transaction-oriented services are in their infancy. In the years to come, they will certainly grow in number and sophistication.

2. Sharing Data Files

Probably no single data communication application is as important to a large business as is the link between its microcomputers and its mainframe computers. In the last few years, businesses have purchased millions of personal computers to increase their employees' productivity. The initial applications of personal computers were stand-alone activities, such as word processing and the use of spreadsheets. To increase productivity further, businesses are taking the additional step of making data stored in mainframe computers available to microcomputer users. The savings including financial ones can be huge.

With data communication and networking, the tasks of data collection, analysis, decision making, report writing and data distribution can be integrated into a single,

efficient system. In effect, the entire office (or even the entire company) becomes one large communication network.

3. Electronic Mail

The smooth operation of a business depends on the efficient exchange of information between different parts of the business and between the business and the outside world. Much of this exchange has been traditionally carried out through paper documents, delivered by secretary, mail or messenger service. With the growing use of personal computers, a more efficient alternative has emerged: electronic mail.

Electronic mail is usually used to exchange messages and data files. Each user is assigned an electronic mailbox. Using the appropriate command, the user can scan a list of messages in the mailbox, display the contents of a particular message, send a message to another user, and so forth. To send a message, it is not necessary for the recipient to be present at the computer. The message resides in the mailbox until it is read.

The sender may restrict delivery of the message to authorised readers by using a password. That is, the recipient must "sign" for the message by typing his or her identifying password.

Many other features of standard mail delivery are implemented in electronic mail systems. For example, mail can be forwarded, stored for delayed delivery and sent to anyone at a particular phone number. In addition, electronic mail systems implement many new features. An electronic mail system can deliver copies of a message to all individuals listed in a certain file. It also allows merging of standard data (from a data file) with a particular message.

Recently, several companies have started subscription to electronic mail services. These services are accessed through a modem and allow users to communicate with other subscribers to the service. The service may also accept a message and transmit it to its destination city. There the message is printed out and delivered with the next day's mail. This technique can be used to communicate with people who are not subscribers to the network.

4. Bulletin Board Systems

Closely related to electronic mail are bulletin board systems. A bulletin board is a communication system that allows users to call in and either leave or retrieve messages. It is similar to an electronic mail system, but there are no private mailboxes, only a single large mailbox. The messages may be directed to all users of the bulletin board or only to particular users. But all messages can be read by all users.

Some computer equipment manufacturers maintain bulletin boards that users may call to determine the status of company products, corrections to programmes, and the like. Users may report problems, ask for literature or place orders. Some computer user groups maintain bulletin boards for notifying members of meetings and other group activities. Other bulletin boards are maintained by individuals as meeting places for like-minded people.